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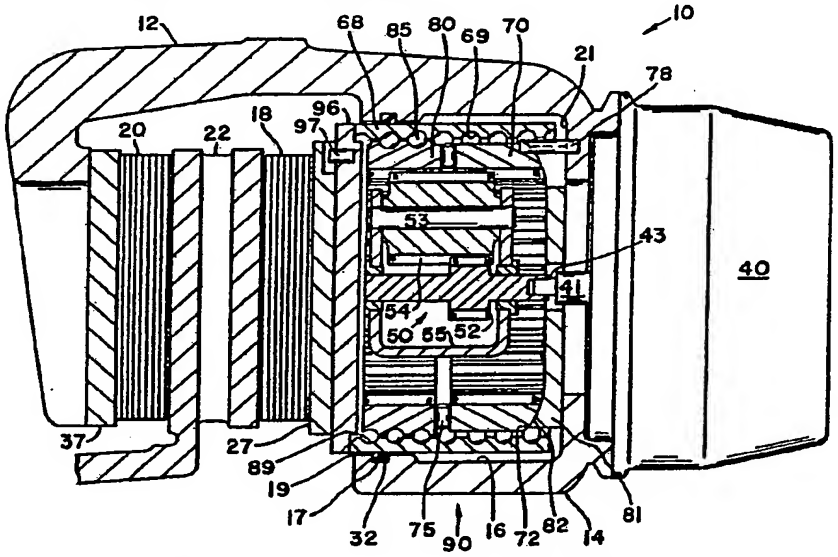

(57) Abstract

The electrically actuated disc brake (10) comprises a caliper (12) having a bore (16) receiving therein an actuating mechanism (90), and an electric motor (40) attached to the caliper housing (12). The actuating mechanism (90) comprises a planetary gear mechanism (50) which includes a sun gear (52), planetary gears (54), and a pair of ring gears (70, 80). An acutator sleeve (68) is disposed about the ring gears (70, 80) and contains a helical groove (69) disposed opposite a complementary-shaped helical groove (89) in a rotatable ring gear (80). The helical grooves (69, 89) receive therebetween a bearing mechanism (85) biased by a spring (87) toward a fixed stop (86) located within the helical grooves (69, 89). Operation of the electric motor (40) effects rotation of the rotatable ring gear (80) and axial displacement of the actuator sleeve (68) into engagement with a thrust pad (96) located adjacent one of the friction elements (18) so that the caliper (12), by reaction, displaces the other friction element (20) into engagement with the rotor (22).

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ELECTRICALLY ACTUATED DISC BRAKE

This invention relates generally to a disc brake that may be operated by a motor connected with a planetary gear mechanism.

Disc brakes have been utilized for many years in passenger cars, heavy duty trucks, and aircraft. Because of the increasing emphasis on reducing the weight of vehicles and simplifying the components thereof, it is desirable to develop a braking system that is operated electrically. Such a braking system must be highly reliable, cost effective, and practical within the packaging constraints of the particular vehicle. The present invention provides a disc brake that may be operated by an electric motor, or other rotary operating motor mechanisms, connected with a planetary gear mechanism. The disc brake may be operated to provide service brake application or to provide a parking brake application. The result is a highly reliable, low cost, electrically operated disc brake which will fit readily within the packaging constraints of several vehicles.

The present invention comprises a disc brake operated by electric motor means, comprising a caliper having a bore aligned with the motor means, the bore having an actuating mechanism disposed therein, the actuating mechanism and caliper actuable to displace a pair of friction elements into engagement with a rotor, characterized in that the actuating mechanism comprises a planetary gear assembly disposed within said bore and comprising a sun gear, a carrier, planetary gears, and a pair of ring gears, the electric motor means coupled with the sun gear which drives the planetary gears, one ring gear fixed to the caliper and the other ring gear rotatable by said planetary gears, an actuator sleeve disposed about the other ring gear, and bearing means disposed between said other ring gear and actuator sleeve, so that operation of said electric motor means effects rotation of the other ring gear and displacement of the bearing means which effects axial displacement of the actuator sleeve to cause one of said friction elements to be displaced and the caliper, by reaction, displacing the other

friction element into engagement with the rotor.

The invention described below with reference to the drawings which illustrate embodiments in which:

Figure 1 is a section view of a first embodiment;

Figure 2 is a partial view of the other ring gear and bearing mechanism;

Figure 3 is a section view of a second embodiment; and

Figure 4 is an isometric view of the nonrotatable ring gear and plate of Figure 3.

The disc brake of the present invention is referenced generally by numeral 10 in Figure 1. Disc brake 10 comprises a brake that is operated by motor means 40. Motor means 40 may comprise an electric motor or other motor mechanisms that provide a rotary output via shaft 41 and coupling 43. Disc brake 10 includes a caliper 12 having a caliper housing 14 with a bore 16. Caliper 12 extends over a pair of friction elements 18 and 20 which may be displaced toward one another in order to brake a rotor 22. The bore 16 comprises a groove 17 adjacent opening 19, and bore end 21. Seal 32 is disposed within groove 17. Located within bore 16 is an actuating mechanism referenced generally by numeral 90. Actuating mechanism 90 comprises a planetary gear assembly 50 which includes a sun gear 52, three planetary gears 54 (the other two not shown in the section view), a carrier 55, pins 53 which carry the planetary gears, two ring gears 70, 80, and thrust bearings 75. Each ring gear has internal teeth, and ring gear 80 is rotatable but has fewer teeth than ring gear 70 which is operatively coupled with caliper housing 14. The planetary gear assembly 50 comprises the planetary gear assembly disclosed in copending Patent Application Serial No. 946,400 entitled "ELECTRICALLY OPERATED DISC BRAKE" which is incorporated by reference herein. Because the two ring gears 70 and 80 have different numbers of teeth, the planetary gear assembly 50 has a high reduction ratio, as

disclosed in copending Serial No. 946,400. Ring gear 70 is rotatably fixed relative to caliper housing 14 by means of a key 78 which is received within complementary-shaped recesses in the caliper housing and ring gear 70. Located between ring gear 70 and bore end 21 is a spherical abutment washer 81 which has a spherical surface 82 that mates slidingly with spherical surface 72 of ring gear 70. The spherical abutment washer has a recess opening which receives key 78 so that it also is nonrotatably fixed relative to caliper housing 14. However, because rotatably fixed ring gear 70 may slide relative to the abutment washer 81, the actuating mechanism 90 may center itself relative to the caliper housing 14. Located about the ring gears is an actuator sleeve 68 having disposed therein a helical groove 69. Rotatable ring gear 80 has a helical groove 89, and a plurality of bearing balls 85 are disposed between the helical grooves 69, 89. As illustrated in Figure 2, the helical groove 89 receives the plurality of balls 85 which engage a fixed stop 86 disposed in groove 89. The fixed stop 86 may be located in either of the helical grooves 89 or 69. A spring 87 also engages a fixed stop (not shown) disposed within either of the grooves and biases the balls 85 toward the fixed stop 86. The balls do not recirculate but are held against the fixed stop 86 when there is no load applied to the bearing balls. The spring 87 allows a limited movement of the bearing balls 86 in the helical groove 89 when the gear 80 is rotated and advances axially the actuator sleeve 68.

Actuator sleeve 68 engages a thrust pad 96 which bears against the backing plate 27 of inner friction element 18, pad 96 restrained from rotating by a pin 97 or by any other alternative keying mechanism.

In operation, mechanism 90 begins from the rest position shown in Figure 1 wherein friction elements 18, 20 are disposed clear of rotor 22. When the driver applies the vehicle brakes, a force-sensitive signal from the brake pedal is sent to a controller (not shown) which

conditions and amplifies the output to supply current to the motor 40. Rotation of motor shaft 41 and sun gear 52 causes ring gear 80 to rotate at a greatly reduced speed so that ball bearings 85 advance actuator sleeve 68 against thrust pad 96 and displace friction elements 18 and 20 into engagement with rotor 22. Axial displacement of element 18 causes caliper 12, by reaction, to displace backing plate 37 and pad friction element 20 into engagement with rotor. Increased brake pedal force increases the current in motor 40 and advances further actuator sleeve 68. When the input signal is released, bearing balls 85 are reversible via spring 87, and this causes ring gear 80 to reverse rotation until only a small load remains on the friction elements. The controller senses release of an applied load and a small reverse current is applied to motor 40 for a predetermined short period of time so that mechanism 90 retracts positively actuator sleeve 68. As a result, bearing balls 85 are in an unloaded condition and spring 87 biases them to a return position against fixed stop 86.

The electrically actuated disc brake provides several distinct advantages. The electric brake is self-powered and needs no pumps or special force multiplying mechanisms. The conventional master cylinder contained in braking systems is eliminated, and all brakes can be independent of one another which provides distinct safety advantages. The brake mechanism provides electrically actuated brakes, positive brake retraction in order to eliminate drag of the friction elements on the rotor, and the mechanism is self adjusting in order to compensate for wear of the friction elements. The electric signals communicated to each disc brake can be modified easily in conjunction with a vehicle anti-skid system, and trailer brakes need only electrical connections.

Figure 2 shows an alternative construction for providing self-alignment of mechanism 90 relative to caliper 12. Rotatably fixed ring gear 70 includes a pair of cylindrical protrusions disposed opposite one another

along a diameter of gear 70. Protrusions 73 are shaped complementary to cylindrical recesses 83 formed in plate 82. Plate 82 includes a plurality of teeth 84 (see Figure 4) which are received within teeth grooves 74 of ring gear 70. Plate 82 is fixed to caliper housing 14. The teeth 84 prevent rotation of ring gear 70 relative to caliper 12. Cylindrical protrusions 73 have their centerline close to the plane of rotation containing seal 32 in order to facilitate rotation of actuator mechanism 90 for alignment purposes.

Other provisions of the invention or variations will become apparent to those skilled in the art and will suggest themselves from the specific applications of the invention. It is intended that such variations and revisions of the invention, as reasonably to be expected on the part of those skilled in the art, to suit individual design preference and which incorporate the herein disclosed principles, will be included within the scope of the following claims as equivalents thereof.

ELECTRICALLY ACTUATED DISC BRAKE

CLAIMS:

1. A disc brake (10) operated by electric motor means (40), comprising a caliper (12) having a bore (16) aligned with the motor means (40), the bore (16) having an actuating mechanism (90) disposed therein, the actuating mechanism (90) and caliper (12) actuatable to displace a pair of friction elements (18, 20) into engagement with a rotor (22), characterized in that the actuating mechanism (90) comprises a planetary gear assembly (50) disposed within said bore (16) and comprising a sun gear (52), a carrier (55), planetary gears (54), and a pair of ring gears (70, 80), the electric motor means (40) coupled with the sun gear (52) which drives the planetary gears (54), one ring gear (70) fixed to the caliper (12) and the other ring gear (80) rotatable by said planetary gears (54), an actuator sleeve (68) disposed about the other ring gear (80), and bearing means (85) disposed between said other ring gear (80) and actuator sleeve (68), so that operation of said electric motor means (40) effects rotation of the other ring gear (80) and displacement of the bearing means (85) which effects axial displacement of the actuator sleeve (68) to cause one of said friction elements (18) to be displaced and the caliper (12), by reaction, displacing the other friction element (20) into engagement with the rotor (22).

2. The disc brake in accordance with claim 1, characterized in that the brake comprises a spherical abutment waster (81) disposed adjacent said one ring gear (70), the spherical abutment washer (81) having a spherical surface (92) mating with a complementary-shaped surface (72) formed on the one ring gear (70) to permit alignment of the actuating mechanism (90) relative to said caliper (12).

3. The disc brake in accordance with claim 2, characterized in that the spherical abutment waster (81) includes an opening receiving therein a key (78), the key (78) anchoring the spherical abutment waster (68) and one ring gear (70) relative to the caliper (12).

4. The disc brake in accordance with claim 1, characterized in that the caliper (12) includes sealing means (32) disposed adjacent an opening (19) of said bore (16), the sealing means (32) engaging an outer surface of said actuator sleeve (68).

5. The disc brake in accordance with claim 1, characterized in that the other ring gear (80) and the actuator sleeve (68) each include circumferential grooves (69, 89) therein, the bearing means (85) disposed in said circumferential grooves (69, 89).

6. The disc brake in accordance with claim 5, characterized in that the bearing means (85) includes resilient means (87) disposed within said grooves (69, 89), the resilient means (87) biasing the bearing means (85) toward an at-rest position.

7. The disc brake in accordance with claim 6, characterized in that the bearing means (85) comprises a plurality of bearing balls (85) which are biased by the resilient means (87) toward a fixed stop (86) contained within one (89) of the grooves (69, 89).

8. The disc brake in accordance with claim 7, characterized in that the circumferential grooves (69, 89) comprise helical grooves (69, 89).

9. The disc brake in accordance with claim 1, characterized in that the brake comprises a face plate (82) disposed between said one ring gear (70) and an end of said bore (16), the one ring gear (70) including, along a diameter thereof, cylindrical protrusion means (73) slidably received within cylindrical recess means (83) formed in the plate (82), so that said actuating mechanism (90) may self-center relative to the caliper (12).

10. The disc brake in accordance with claim 9, characterized in that the face plate (82) includes a plurality of axial teeth (84) which are received within complementary shaped openings (74) in the one ring gear (70), so that the one ring gear (70) is positioned nonrotatably relative to the caliper (12).

AMENDED CLAIMS

[received by the International Bureau on 18 October 1988 (18.10.88); original claim 1 amended; remaining claims unchanged (2 pages)]

1. A disc brake (10) operated by electric motor means (40), comprising a caliper (12) having a bore (16) aligned with the motor means (40), the bore (16) having an actuating mechanism (90) disposed therein, the actuating mechanism (90) and caliper (12) actuatable to displace a pair of friction elements (18, 20) into engagement with a rotor (22), characterized in that the actuating mechanism (90) comprises a planetary gear assembly (50) disposed within said bore (16) and comprising a sun gear (52), a carrier (55), planetary gears (54), and a pair of ring gears (70, 80), the electric motor means (40) coupled with the sun gear (52) which drives the planetary gears (54), one ring gear (70) connected with the caliper (12) and the other ring gear (80) rotatable by said planetary gears (54), an actuator sleeve (68) disposed about the other ring gear (80), and bearing means (85) disposed between said other ring gear (80) and actuator sleeve (68), so that operation of said electric motor means (40) effects rotation of the other ring gear (80) and displacement of the bearing means (85) which effects axial displacement of the actuator sleeve (68) to cause one of said friction elements (18) to be displaced and the caliper (12), by reaction, displacing the other friction element (20) into engagement with the rotor (22).

2. The disc brake in accordance with claim 1, characterized in that the brake comprises a spherical abutment waster (81) disposed adjacent said one ring gear (70), the spherical abutment washer (81) having a spherical surface (92) mating with a complementary-shaped surface (72) formed on the one ring gear (70) to permit alignment of the actuating mechanism (90) relative to said caliper (12).

3. The disc brake in accordance with claim 2, characterized in that the spherical abutment waster (81) includes an opening receiving therein a key (78), the key (78) anchoring the spherical abutment waster (68) and one ring gear (70) relative to the caliper (12).

4. The disc brake in accordance with claim 1, characterized in that the caliper (12) includes sealing means (32) disposed adjacent an opening (19) of said bore (16), the sealing means (32) engaging an outer surface of said actuator sleeve (68).

5. The disc brake in accordance with claim 1, characterized in that the other ring gear (80) and the actuator sleeve (68) each include circumferential grooves (69, 89) therein, the bearing means (85) disposed in said circumferential grooves (69, 89).

6. The disc brake in accordance with claim 5, characterized in that the bearing means (85) includes resilient means (87) disposed within said grooves (69, 89), the resilient means (87) biasing the bearing means (85) toward an at-rest position.

7. The disc brake in accordance with claim 6, characterized in that the bearing means (85) comprises a plurality of bearing balls (85) which are biased by the resilient means (87) toward a fixed stop (86) contained within one (89) of the grooves (69, 89).

8. The disc brake in accordance with claim 7, characterized in that the circumferential grooves (69, 89) comprise helical grooves (69, 89).

9. The disc brake in accordance with claim 1, characterized in that the brake comprises a face plate (82) disposed between said one ring gear (70) and an end of said bore (16), the one ring gear (70) including, along a diameter thereof, cylindrical protrusion means (73) slidably received within cylindrical recess means (83) formed in the plate (82), so that said actuating mechanism (90) may self-center relative to the caliper (12).

10. The disc brake in accordance with claim 9, characterized in that the face plate (82) includes a plurality of axial teeth (84) which are received within complementary shaped openings (74) in the one ring gear (70), so that the one ring gear (70) is positioned non-rotatably relative to the caliper (12).

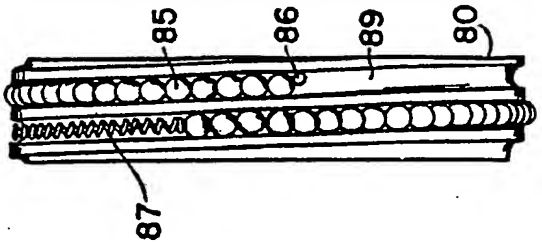
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FIG. 2

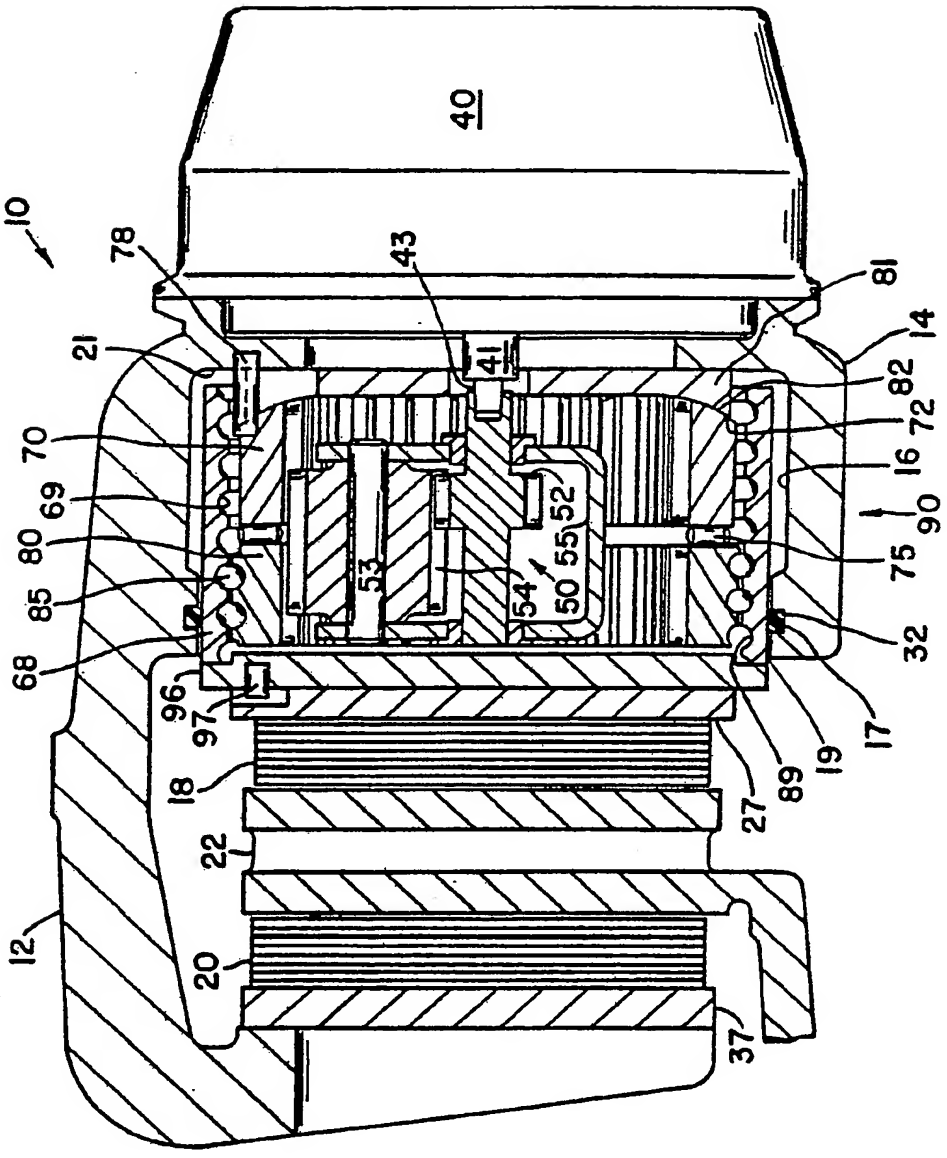
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FIG. 1

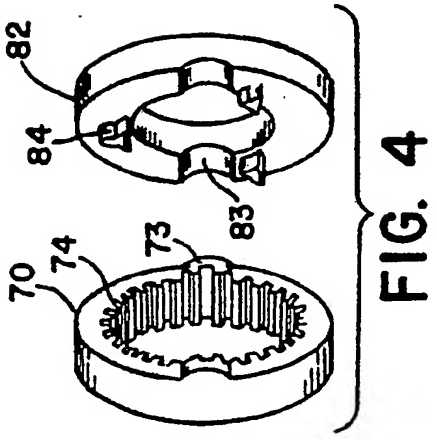

FIG. 4

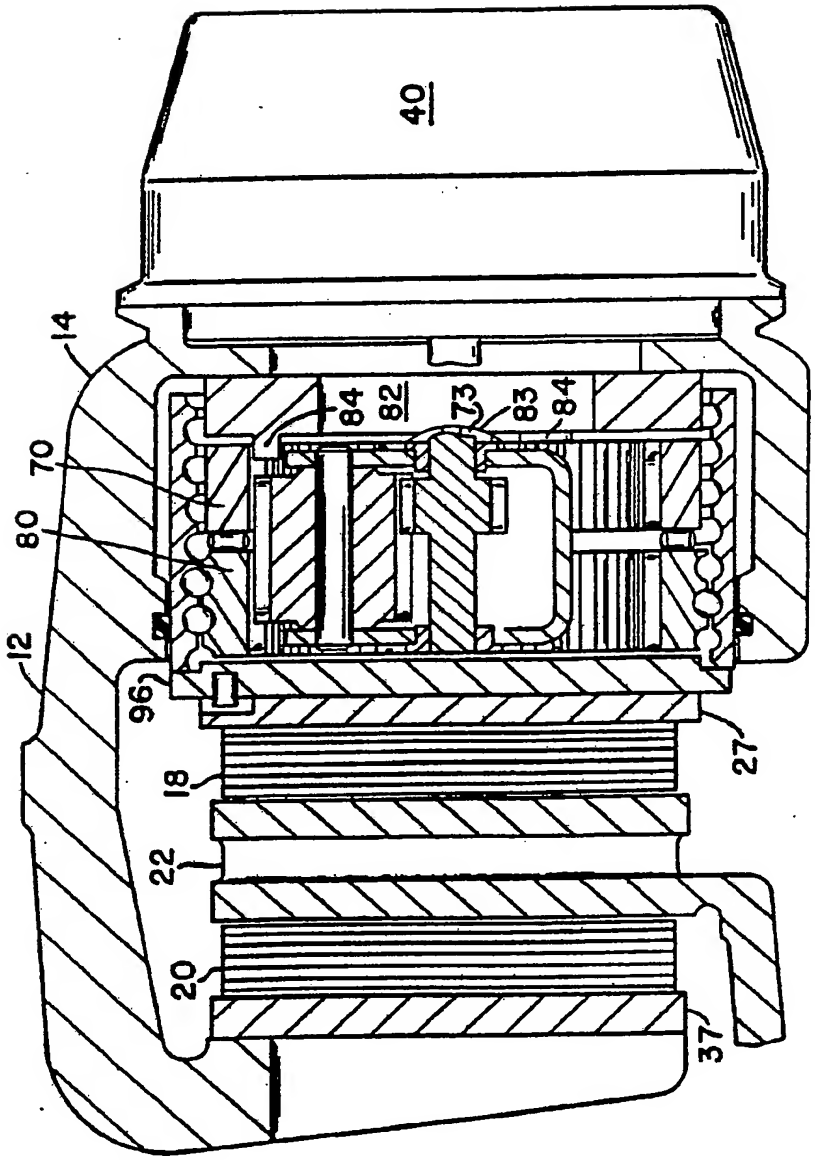

FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 88/01111

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: F 16 D 65/16; F 16 D 63/00; B 60 T 13/74; F 16 D 55/224

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[4]	F 16 D 65/00; F 16 D 55/00; B 60 T 13/00; B 60 T 8/00

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	GB, A, 2156021 (ALFRED TEVES GmbH) 2 October 1985, see the whole document	1,5-8
A	EP, A, 0129969 (WESTINGHOUSE BRAKE AND SIGNAL CO., LTD) 2 January 1985, see page 24, line 31 - page 25, line 35; figures 1,2,5	1,5-8
A	EP, A, 0109918 (GOODYEAR AEROSPACE CORP.) 30 May 1984, see figures 1-4	5-8
A	DE, A, 3423510 (KNORR-BREMSE GmbH) 2 January 1986, see figure 2	1

* Special categories of cited documents: [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
9th August 1988	26. 08. 88
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	P.C.G. VAN DER PUTTEN

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. US 8801111 SA 22459

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 18/08/88
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		US-A-	4546298	08-10-85
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		AU-B-	559873	19-03-87
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		CA-A-	1224424	21-07-87
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